However, on the whole, the findings in McKinsey (1995), Rothstein (1994), and this thesis are similar.

The latest research in this area, Glennan and Melmed (1996), takes a different approach to examining costs. The report presents an in-depth analysis of the technology costs for five technologically advanced schools and three technologically average schools across the U.S.

Within the schools studied, funds spent annually per pupil on technology was in the $180-$450 range. The report recommends a $300 target for U.S. schools, which represents a 300% increase over the current actual technology expenditures in schools. The report admitted that a fundamental shift in the country's thinking about educational technology will be necessary to secure such an increase in funds. The report also stated that, although there is some research attesting to the effectiveness of technology in schools, more research is necessary to make conclusive statements about its educational value.

The report examines all computer technology costs with the schools and does not record separate line items for networking infrastructure. It ignores the significant one-time costs associated with rapid deployment of networking and NII connectivity (including LAN installation and Internet connectivity setup). Finally, the small sample size (eight schools) used in the report represents a case study of educational technology and does not necessarily provide results generalizable to the entire U.S. education system.

The recent emergence of these studies on the costs and benefits of computer networking in schools begins to supply some information in this area. However more research, particularly research syntheses of cost and benefit data, is necessary to support informed debate on the role of computer networking in schools.

1.5 THESIS OVERVIEW

Chapter two presents a set of five technology models, each of which represents an increasing level of telecommunications infrastructure in a school. The chapter describes the technical capabilities and the initial and ongoing costs for each model. Cost projections for all U.S. public schools are determined by aggregating the school cost data. The aggregate cost data is used to determine the financial benefits of various policies that may reduce the total costs to wire up schools.[10]

Chapter three examines the benefits of computer networking in schools. It provides a brief survey of current research on the benefits of educational technology and educational networking. It describes the types of services that schools can receive for each of the five architecture models developed in chapter two. The chapter presents a case study of the benefits of high-speed educational networking at Lexington High School. Due to its significant investment in networking, the school is able to make use of a new educational service, Internet CNN NEWSROOM. The chapter describes the benefits the school receives from using networked multimedia services such as Internet CNN NEWSROOM.

Chapter four explores policy and product recommendations in educational networking. The policy recommendations are directed at policy makers, regulators, and school officials to reduce costs and increase benefits for schools. The product recommendations are directed at educational software developers and publishers to identify the features of Internet-based educational products that meet the needs of teachers and students.

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[10] The results in this chapter are based on Rothstein (1994) and represent work done initially at the U.S. Department of Education and subsequently at the MIT Research Program on Communications Policy. Initial cost data was collected through research done at the Department of Education. Subsequent research at MIT has provided updated cost estimates.

Chapter Two

Architecture Models and Costs

2.1 INTRODUCTION

Estimating the costs of telecommunications services in K-12 schools in the U.S. is a daunting task. Each of the 110,000 public and private schools across the country has different needs for technology expenditures. Some schools hold technology in great esteem and desire to have more resources at their disposal. Other schools see technology as irrelevant or unhelpful in educating children. Because local funding constitutes the majority of a school's budget, the financial resources available to schools varies by community and state. In communities that allocate significant funds for education, schools have the financial resources to purchase modern, powerful computers and other technology. In communities that choose not to or are unable to allocate abundant financial resources to education, schools are unable to make significant technology expenditures. Additionally, the amount of technology currently found in schools varies greatly; in some schools computers and technology are ubiquitous, while in other schools high-tech equipment is an electric pencil sharpener and a touch-tone telephone.

The variety of technology needs and resources is due to the decentralized, autonomous nature of the public and private school systems in the country. There is no centralized planning authority for U.S. schools. The U.S. Department of Education, created in 1980, promotes education in the country but does not have any power or authority over schools. Therefore, the rate of adoption of technology in schools will continue to vary from school to school.

Given a diverse technology adoption rate among schools, this chapter presents a series of five technology models for schools in connecting to a national information infrastructure. Each of the five models has a different level of technical complexity, cost, and functional capability. Schools will migrate to different models based on their own needs and financial resources for technology. However, to take advantage of many of the networked multimedia educational services, schools will require a minimum level of connectivity and technical infrastructure. This chapter examines the total costs of networking K-12 schools through five models and evaluates the impact of cost savings programs.

2.2 COST MODELS OF K-12 NETWORKING

Networking K-12 schools is not a one-shot deal. Technology is a recurring expenditure for schools since they require continual equipment upgrades and purchases. The five technology models described in this chapter represent a continuum of telecommunications infrastructure construction that schools may implement over time in establishing broadband network connectivity.

Every year, schools answer two key questions concerning the use of funds to purchase technology:

- What additional capabilities do we desire that will be enabled through technology?
- How will we allocate our expenditures to achieve those capabilities?

The former question provides the impetus for the technology models developed in this chapter. Each successive model presents an expansion of the features and capabilities available with expanded digital telecommunications infrastructure. As the model increases in functionality, the costs to implement the model increase as well. The models do not address the issues of fund allocation among different technologies and products as described in the latter question.

A school will likely begin its connection to a data communications network with a simple, low-cost configuration. As the school builds expertise and develops a need for greater capability, it will upgrade to a higher level of connectivity. Not until the school acquires telecommunications infrastructure similar to the fourth model is it able to take advantage of multimedia educational services. The fifth model presents the costs for putting a PC on every desktop along with a high-speed Internet connection.

These models are representations of the network technology used in schools. While a level of complexity and detail is omitted from these models, the simplicity is helpful because the models encompass broad cross-sections of network and school configurations.

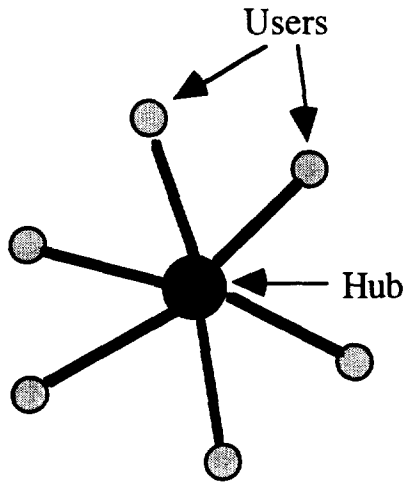
The scope of the school networking models includes digital data communications networking based on Internet networking technology. Analog video point-to-point networks, analog voice networks and voice-mail systems are beyond the scope of these models. Audio and video functions are possible in digital format over the Internet data network, but many schools will still use separate video and voice networks. The costs of these systems are important to consider, but are not modeled in this thesis.

Although these models exclude voice and video networks, schools should not consider these networks to be wholly distinct from data networks. Some schools have integrated their voice and video networks with the school data network. The sharing of resources among the multiple networks can be effective in providing significant cost savings. As a school installs a LAN and puts computer data connections in every classroom, there are minimal added costs to concurrently install other types of connections.

2.2.1 Architecture of the District Network

The star network architecture, illustrated in Figure 1, is the underlying design for the models. The star network connects multiple sites to a central hub.[11] In the school network, each school building is connected to the school central hub. In most cases, the district office is the most appropriate site for the central hub, because it also represents the bureaucratic center of the district.

Figure 1. Star Network



SOURCE: Newman, Bernstein, and Reese (1992)

From two to ten schools should connect to a single hub, depending on the size of the schools. In most cases, the hub will reside at the school district office. However, in cases where there are a great number of schools in a single district, the district should be divided into multiple clusters of 4-6 schools each. Each of these school-clusters will have a group hub, probably at the district office, which will contain the center of the network for those schools.

[11] Many telecommunications networks are built using a star network design. Internet service provision and local loop telephony provide two examples among many. In the former case, subscribers dial in to the Internet service provider's central hub from where they connect to the Internet. In the latter case, all homes in an area are connected to a central office switch, through which all calls are routed.

There should be a connection between the school LAN and the district office hub. With this configuration, every classroom has a connection not only to every other class in the school but also to the central school district office. The connection from the district office to the Internet should be a higher bandwidth connection since all schools are connecting to the Internet through this single line.

Schools can reap significant cost savings through adoption of the star architecture design. When multiple schools connect through a single hub, schools share network costs. Since networking infrastructure contains economies of scale, each school pays less for its share of the total cost than if it connected separately.

This design gives schools stronger purchasing power since school districts can negotiate volume discounts for purchase of equipment for the entire district. The design also allows schools to share resources, such as the data line to the Internet, training programs, and full-time support staff, that each school might not be able to afford individually. Therefore there are costs both at the school and at the district level for networking schools across the country. Sellers and Robichaux (1995) and California Department of Education (1994) also advocate the use of a star configuration through a community or district hub.

Schools have benefited most from technologies that are mature and reliable. Cutting-edge technologies have been less successful in schools due to the instability of the technologies and the large amount of resources required to support them. The models assume the use of mature technology and transmission media. Therefore, this thesis excludes new technologies such as wireless and coax-fiber hybrid systems. However, given the rapidity of technological change and marketplace evolution for networking products and services, there is a need for research and evaluation of wireless and cable alternatives in schools.

2.2.2 Cost Areas

The cost models presented in this paper include four types of costs – hardware, training, support, and retrofitting. The items included in these categories are:

- Hardware – Hardware includes wiring, router, server, PCs, including installation, maintenance, and service of the hardware and telecommunications lines.
- Training – Training includes instruction of teachers and other school staff on use of the network.
- Support – Support includes technical support of the network.
- Retrofitting – Retrofitting includes modifications to the school facility to accommodate the telecommunications infrastructure. This may include costs for asbestos removal, electrical systems, climate control systems, added security (e.g., locks, alarms, and surveillance equipment,) and renovation of buildings to accommodate network installation and operation.

The following cost area is outside the scope of the models:

- Educational software – This thesis does not include the costs for educational software and applications. It assumes that schools use free educational versions of Internetworking software, such as web browsers and email applications, that schools can download over the network. Schools may desire to purchase commercial educational software programs. The costs for this software may be high, but are not included in the models. Further economic analysis of software costs and their evolution in the network scenarios analyzed below is necessary.

2.2.3 School Characteristics

The models describe the costs for a typical school and school district, as derived from U. S. Department of Education (1994), and represent the average costs of all U.S. schools and school districts. Many schools will differ in significant ways from the typical school, and will therefore face somewhat different costs than those presented in the models.

The average school has about five hundred students and twenty classrooms. It employs 27 teachers and 25 other school staff. The average number of schools in a school district is about six.[12]

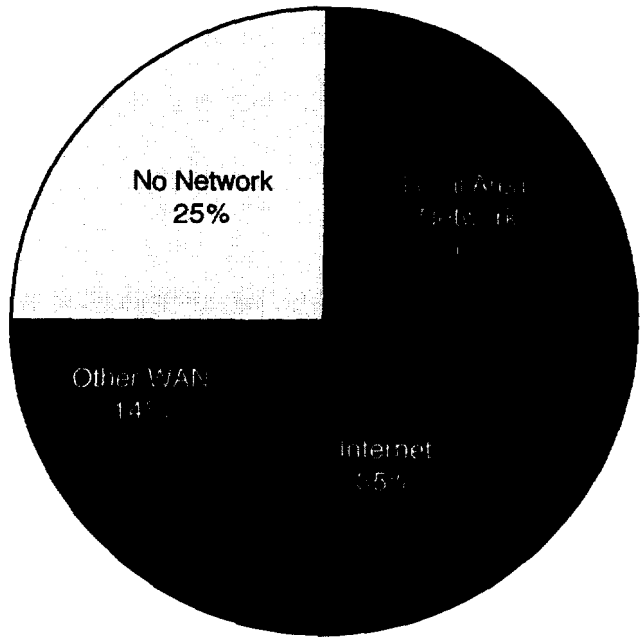
In 1992 there were, on average, 23 computers in each elementary and secondary school, and 47 computers in each upper secondary school.[13] About 15% of these machines, or 3-7 machines per school, are capable of running the network protocol (TCP/IP) to access the Internet. During the three years from 1989 until 1992, the number of computers in schools grew by 50%. Using a 50% growth rate since 1992, there are, on average, approximately seven networkable PCs in every school. Seven PCs is sufficient for the first two models, but is not sufficient for establishing multiple connections in every classroom throughout the school. Therefore, from model three upwards, there is a line-item cost for purchasing additional PCs.

National Center for Education Statistics, U. S. Department of Education (1995), provides a profile of networking in schools across the country, as illustrated in Figure 2. One-quarter of schools has neither a LAN nor a connection to a WAN. Twenty-six percent of schools have a local area network but no connection outside the school. Thirty-five percent of schools have an Internet connection along with the school LAN. The remaining 14% of schools use their LAN to

[12] The projections assume a national enrollment of approximately 44 million students in 85,000 public schools within 15,000 school districts.
[13] Anderson (1993), p. 14.

connect to another WAN, usually a commercial on-line service such as America Online and Compuserve.

Figure 2. Network Access of U.S. Public Schools



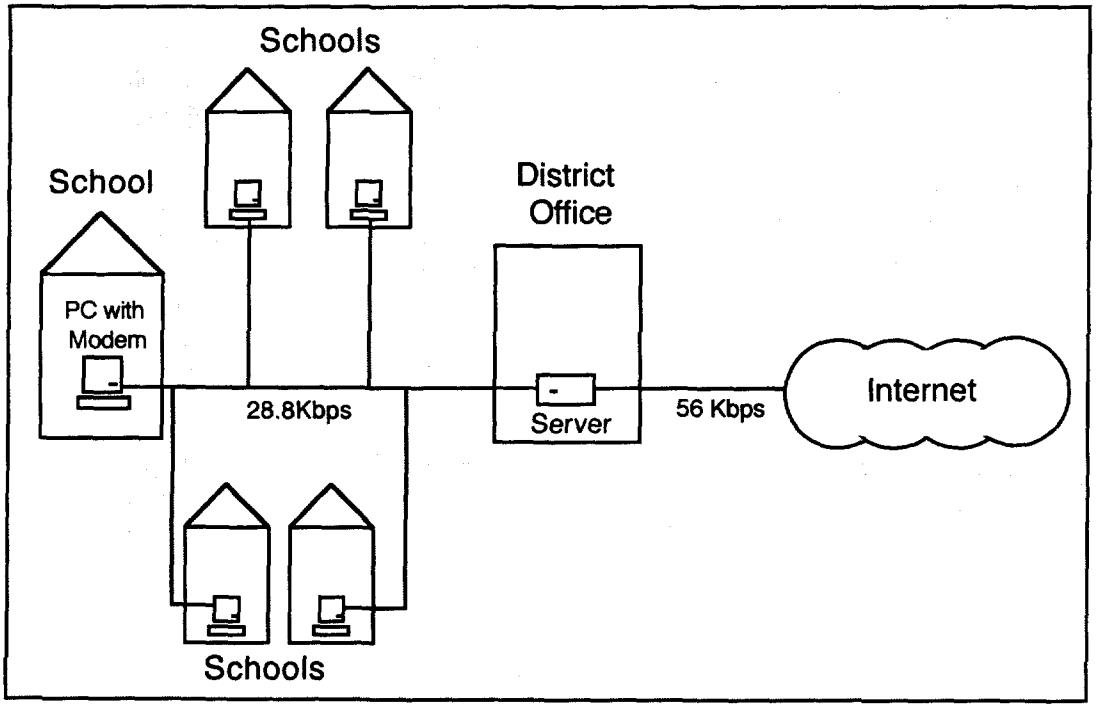
Source: National Center for Education Statistics, U. S. Department of Education (1995)

2.2.4 Cost Models

MODEL 1: SINGLE PC DIALUP

Model one, illustrated in Figure 3, represents the most basic connectivity option for a school. The school has no internal LAN within the building. There is a single connection to the district office over a modem and standard phone line. The district office connects to the Internet through a 56Kbps line from its server.

Figure 3. Single PC Dialup Model



SOURCE: Rothstein (1994)

This model is a low-cost option for schools. Many of the services and benefits envisioned for the NII will not be widely accessible in schools using this model. Given the limited functionality of the system, only a few teachers in the school require training.

Table 1 lists the cost items associated with this model.

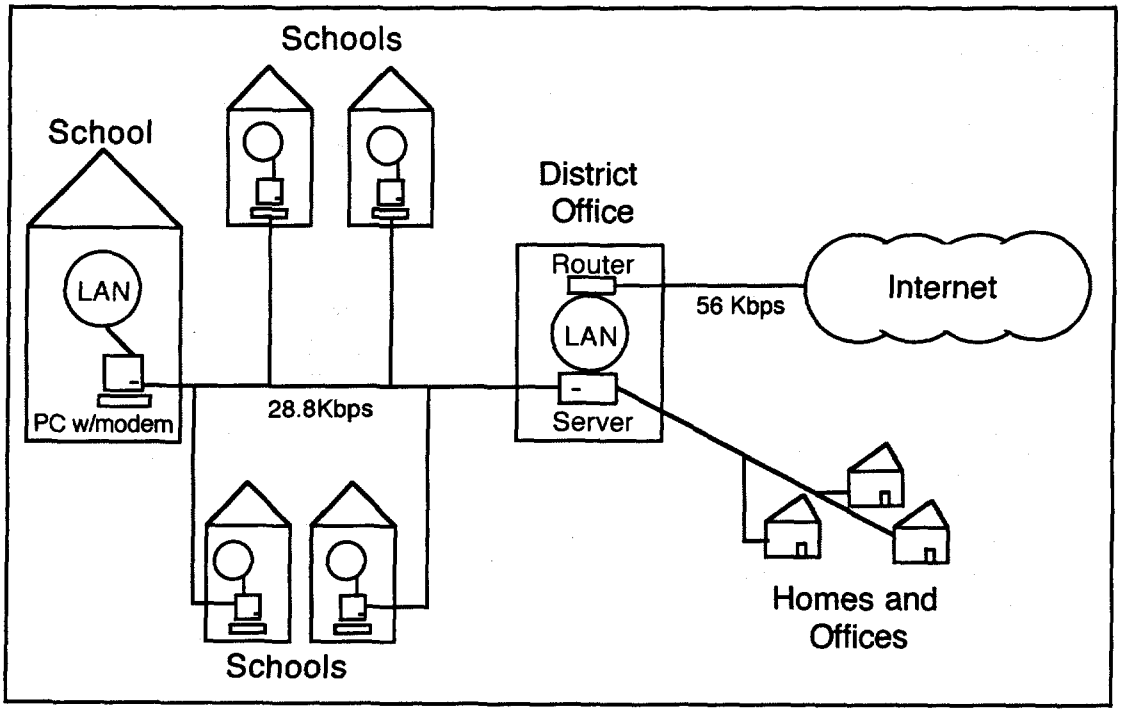
Table 1. PC Dialup Model Costs

		Low	High
SCHOOL COSTS			
One-time Installation Costs			
Telephone Line		$100	$250
Modem		$100	$250
	Total:	$200	$500
Annual Operating Costs			
Replacement of equipment		$50	$150
Telephone line (10 hrs/month)		$150	$1,000
	Total:	$200	$1,150
DISTRICT OFFICE COSTS			
One-time Installation Costs			
File Server		$2,000	$10,000
Data line to WAN/Internet (56Kb)		$500	$2,000
Training (2-4 teachers per school)		$1,000	$10,000
	Total:	$3,500	$22,000
Annual Operating Costs			
Internet service (56Kbps)		$3,000	$10,000
Support		$2,000	$10,000
Training		$1,000	$5,000
	Total:	$6,000	$25,000
TOTAL U.S. ONE-TIME COSTS		$0.07 B	$0.37 B
One-Time Costs Per Student		$1.58	$8.47
TOTAL U.S. ANNUAL COSTS		$0.11 B	$0.43B
Annual Costs Per Student		$2.43	$9.78

MODEL 2: LAN WITH SHARED MODEM

In model two, as illustrated in Figure 4, there exists a LAN within each school. By connecting the modem to the LAN, every computer on the network has access to the Internet. However, this model supports only a few users at a time, limited by the number of phone lines going out of the school. The model includes modems and phone lines, so that faculty, students, and parents can gain access to the school system remotely on weekends and after school hours.

Figure 4. LAN with Shared Modem Model



SOURCE: Rothstein (1994)

The cost for installation of the LAN in each school is significant. This model assumes the use of copper wire (category 5) as the medium for the network since it is presently the most affordable and scalable option for schools. The model requires a $100 - $150 cost for the wiring and network cards for every networked computer. Including the costs for the accompanying hardware and labor, the costs per PC are $400 - $500. Therefore, for the school model with 60

- 100 connected PCs (3-5 PCs per classroom @ 20 classrooms), the total LAN costs are $20,000 - $55,000.

Model two also is a relatively low-cost option for schools. However, many of the services and benefits envisioned for the NII are still not widely accessible in this model. Table 2 lists the cost items associated with this model:

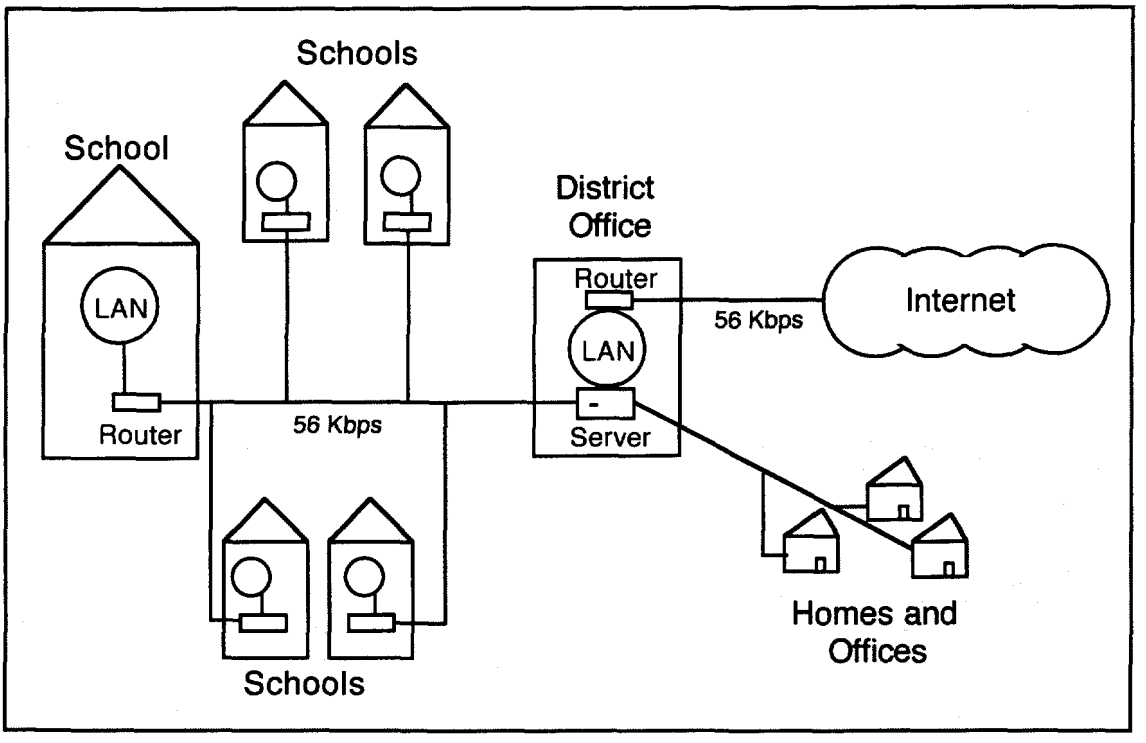
Table 2. LAN with Shared Modem Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$20,000	$55,000
LAN Modem	$300	$1,000
Retrofitting (minor)	$2,000	$10,000
Total:	$22,300	$66,000
Annual Operating Costs		
Replacement of equipment	$3,000	$8,250
Shared telephone line (40 hrs / month)	$600	$2,000
Total:	$3,600	$10,250
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$10,000
District Local Area Network	$2,000	$5,000
Data line to WAN/Internet (56Kb)	$500	$2,000
Dialup Capabilities (2 lines)	$2,000	$4,000
Training (train 5-20 staff per school)	$1,000	$10,000
Total:	$7,500	$31,000
Annual Operating Costs		
Internet service (56Kbps)	$3,000	$10,000
Dialup Lines	$300	$500
Support (1-2 staff per district)	$45,000	$90,000
Training	$10,000	$20,000
Total:	$58,300	$120,500
TOTAL U.S. ONE-TIME COSTS	$2.01 B	$6.08 B
One-Time Costs Per Student	$45.64	$138.07
TOTAL U.S. ANNUAL COSTS	$1.18 B	$2.68 B
Annual Costs Per Student	$26.83	$60.88

MODEL 3: LAN WITH ROUTER

In this model, as illustrated in Figure 5, each school uses a router instead of a modem to connect to the district office hub. With the router, multiple LAN users within the school may access the Internet concurrently.

Figure 5. LAN with Router Model



SOURCE: Rothstein (1994)

Since the router allows multiple users of the system, there is an opportunity to expand the entire network infrastructure. With this infrastructure, it is reasonable to support one PC in every classroom. Therefore, there is a requirement to purchase 15 additional PCs for the average school to use in addition to its small initial stock of TCP/IP-compatible machines. Assuming district-level purchasing, the district is able to negotiate favorable PC prices ($1,000 - $2,000 each). Support and training costs are higher since there are additional users of the system.

Additional dialup lines are required to accommodate remote access. There are also significant retrofitting costs for the electrical system, climate control system, and enhanced security.

Table 3 lists the cost items associated with this model.

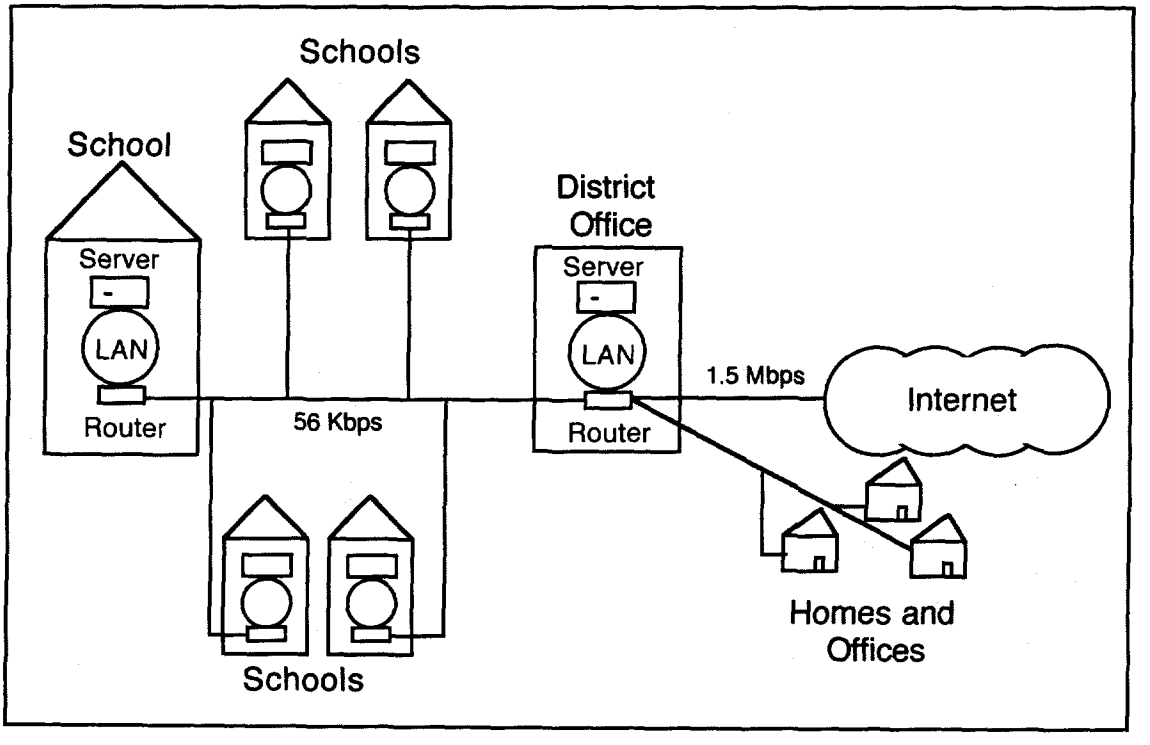
Table 3. LAN with Router Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$20,000	$55,000
Personal Computers (15 machines)	$15,000	$30,000
Router	$1,000	$3,000
Connection to Hub (14.4 Kb or 56Kb)	$50	$1,000
Retrofitting (major)	$10,000	$25,000
Total:	$47,050	$114,000
Annual Operating Costs		
Replacement of equipment	$3,000	$8,250
Connection to Hub (14.4 Kb or 56Kb)	$500	$10,000
Total:	$3,500	$18,250
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$15,000
Router	$2,000	$5,000
District Local Area Network	$1,000	$5,000
Data line to WAN/Internet (56Kb)	$500	$2,000
Dialup Capabilities (8 lines)	$8,000	$16,000
Training (10-20 staff per school)	$1,000	$10,000
Total:	$15,500	$53,000
Annual Operating Costs		
Internet service (56Kbps)	$5,000	$10,000
Dialup Lines	$1,200	$2,000
Support (1-2 staff per district)	$45,000	$90,000
Training	$10,000	$20,000
Total:	$61,200	$122,000
TOTAL U.S. ONE-TIME COSTS	$4.13 B	$10.49 B
One-Time Costs Per Student	$93.90	$238.30
TOTAL U.S. ANNUAL COSTS	$1.22 B	$3.38 B
Annual Costs Per Student	$27.63	$76.85

MODEL 4: LAN WITH LOCAL SERVER AND DEDICATED LINE

In this model, as illustrated in Figure 6, a local file server in every school gives schools the ability to store information locally without accessing the district network. There is a higher bandwidth connection from the district office to the Internet (1.5 Mbps) to allow greater Internet access.

Figure 6. LAN with Local Server and Dedicated Line Model



SOURCE: Rothstein (1994)

In this model, the network can effectively serve the entire school. As a result, the model requires an extensive training program and a well-staffed support team. The cost of the connection to the Internet is also higher due to the larger bandwidth connection. There are significant retrofitting costs for the electrical system, climate control system, and enhanced security.

Table 4 lists the cost items associated with this model.

Table 4. LAN with Local Server and Dedicated Line Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$20,000	$55,000
Personal Computers (60 machines)	$60,000	$120,000
File Server	$2,500	$15,000
Connection to Hub/District Office (56Kb)	$500	$2,000
Router and CSU/DSU	$2,600	$5,000
Retrofitting (major)	$10,000	$25,000
Total:	$95,600	$222,000
Annual Operating Costs		
Replacement of equipment	$3,000	$8,250
Connection to Hub/District Office (56Kb)	$1,000	$5,000
Total:	$4,000	$13,250
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$15,000
Router	$1,000	$5,000
District Local Area Network	$1,000	$5,000
Data line to WAN/Internet (1.5 Mbps)	$1,000	$5,000
Dialup Capabilities (20 lines)	$16,000	$32,000
Training (40-50 staff per school)	$50,000	$150,000
Total:	$71,000	$212,000
Annual Operating Costs		
Internet service (1.5 Mbps)	$10,000	$42,000
Dialup Lines	$2,000	$5,000
Support (2-3 staff per district)	$66,000	$150,000
Training	$15,000	$35,000
Total:	$93,000	$232,000
TOTAL U.S. ONE-TIME COSTS	$9.19 B	$22.05 B
One-Time Costs Per Student	$208.89	$501.14
TOTAL U.S. ANNUAL COSTS	$1.74 B	$4.61 B
Annual Costs Per Student	$39.43	$104.69

Using this model as a baseline for connecting to the NII, these figures are indicative of the costs of connecting K-12 schools across the country to the NII.[14] These estimates indicate that there

[14] As described in Information Infrastructure Task Force (1994), the NII:

> promises every...school...in the nation access anywhere to voice, data, full-motion video, and multimedia applications. Through the NII, students of all ages will use multimedia electronic libraries and museums containing text, images, video, music, simulations, and instructional software.

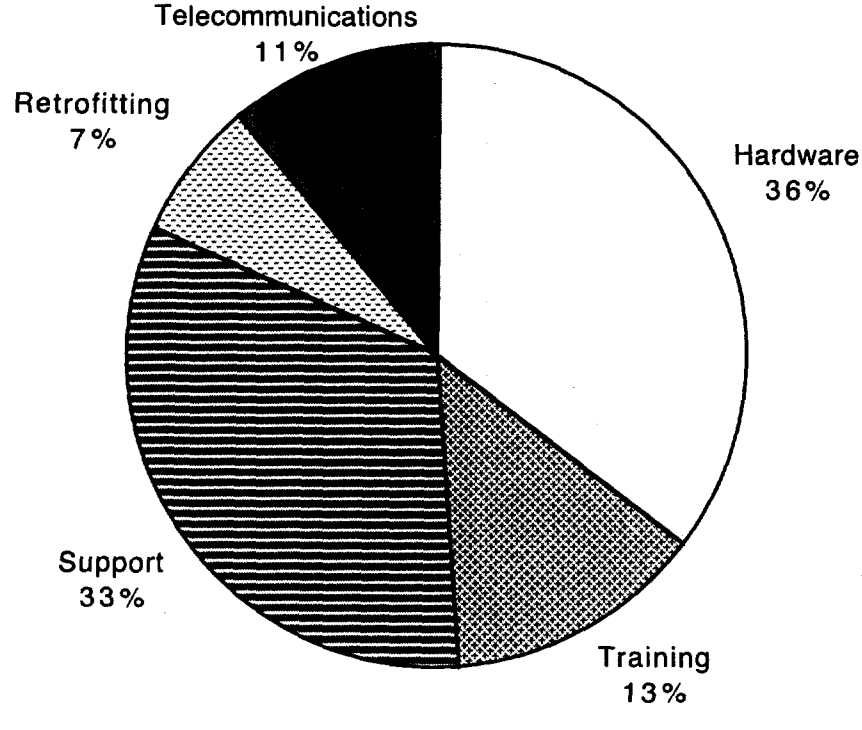
In models four and five, the school has access to these NII services.

will be $9.2B - $22.1B in one-time costs with annual maintenance costs of $1.7B - $4.6B. At the per pupil level, this is equivalent to $209 - $501 in one-time installation costs and an ongoing annual cost of $39 - $105.

In this model, hardware is the most significant cost item for schools. The cost for PC purchases represents more than half of the one-time installation costs. However, the value of the PCs goes well beyond their use as networking devices. Therefore, the costs for PC purchases should be allocated across other parts of the technology budget, and not only to the networking component. By allocating the PC costs to other budget items, the hardware costs for network connectivity drop considerably.

Figure 7 illustrates the average of low and high cost estimates, excluding PC purchases over the first five years of deployment.

Figure 7. Breakdown of Costs for Model Four



SOURCE: Rothstein and McKnight (1995)

These projections assume amortization of the initial startup costs over five years using the straight-line method. Costs for support of the network represent about one-third of all networking. Support is a vital part of the successful implementation of a school network. Therefore, it is important that schools and districts allocate sufficient budget amounts for support. Support and training together comprise 46% of the total costs of networking schools. Costs for telecommunications lines and services represent only 11% of the total costs. This amount is lower than the costs assumed by much of the technology community, including the telecommunications service and equipment providers.

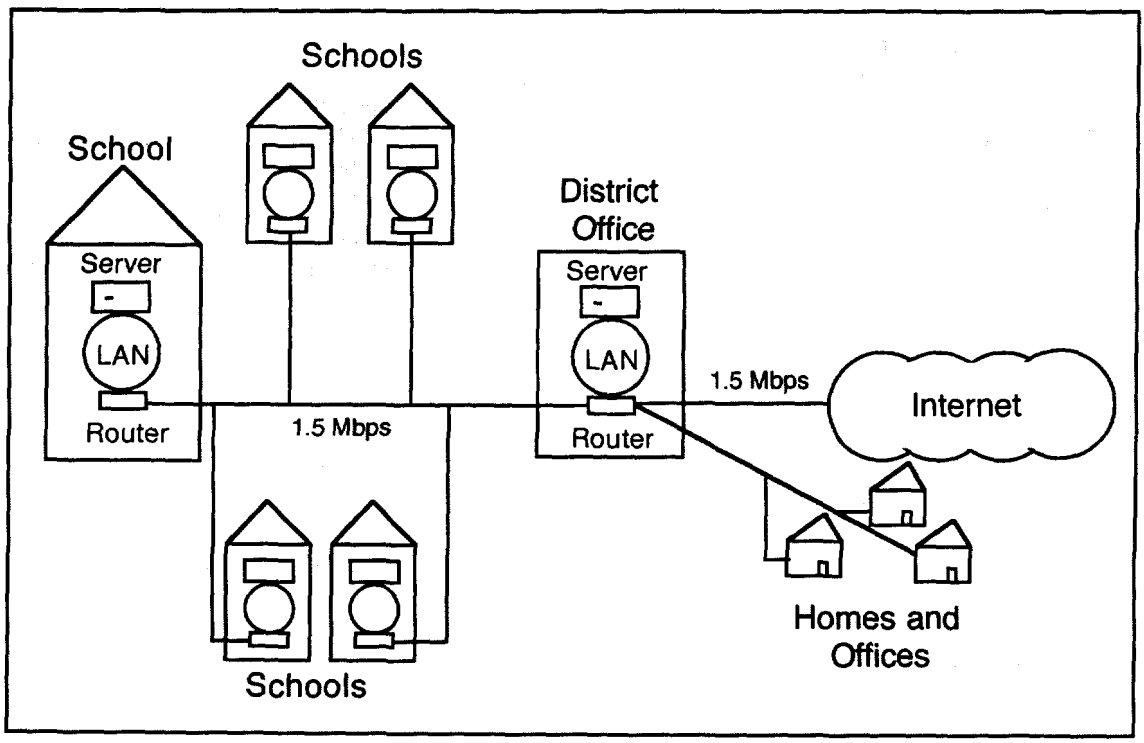
Schools today are not allocating their technology budgets effectively for this cost structure. Overall, districts spend less than fifteen percent of their technology budgets on training, but they spend fifty-five percent of the budget on hardware and thirty percent on software. Furthermore, only six percent of elementary and three percent of secondary schools have a full-time, school-level computer coordinator for technical support.[15]

[15] U.S. Congress, Office of Technology Assessment (1995), p. 19.

MODEL 5: UBIQUITOUS LAN W/LOCAL SERVER AND HIGH-SPEED LINE

Model five, as illustrated in Figure 8, represents a full, ubiquitous connection to the NII. In this model, there is a PC on the desktop of every student and teacher. A high-bandwidth connection to the school supports large numbers of concurrent users of the system.

Figure 8. Ubiquitous LAN with Local Server and High-Speed Line Model



SOURCE: Rothstein (1994)

In this model, the network can effectively connect every desk in every classroom. A majority of the expenditures for this model are made to put PCs on every desktop. Since there are five hundred students in an average school, every school requires approximately 450 new PCs. Since the network is ubiquitous, the model requires an extensive training program and a well-staffed support team. The cost of the connection to the Internet is also higher due to the high-speed line going into the school. The file server is larger to accommodate the large number of

networked PCs. The dialup system is larger to allow many students, teachers, and parents to access the system remotely. The retrofitting costs are substantial since the typical school requires extensive electrical work to accommodate the hundreds of new PCs that consume voltage and produce heat. In addition, the model school makes expenditures on air conditioners and security locks to protect the new equipment.

Table 5. Ubiquitous LAN with Local Server and High-Speed Line Model Costs

	Low	High
SCHOOL COSTS		
One-time Installation Costs		
Local Area Network	$40,000	$100,000
File Server	$2,000	$15,000
Connection to Hub/District Office (1.5 Mbps)	$1,200	$5,000
Router and CSU/DSU	$25000	$7,000
PC on every desk (450 new machines)	$450,000	$900,000
Retrofitting (major including electrical)	$70,000	$250,000
Total:	$565,700	$1,277,000
Annual Operating Costs		
Replacement of equipment	$6,000	$15,000
Connection to Hub/District Office (1.5 Mbps)	$8,000	$35,000
Total:	$14,000	$50,000
DISTRICT OFFICE COSTS		
One-time Installation Costs		
File Server	$2,000	$15,000
Router	$2,000	$5,000
District Local Area Network	$2,000	$5,000
Data line to WAN/Internet (1.5 Mbps)	$1,000	$5,000
Dialup Capabilities (50 lines)	$16,000	$80,000
Training (all teachers in school)	$55,000	$165,000
Total:	$78,000	$275,000
Annual Operating Costs		
Internet service (1.5 Mbps)	$10,000	$42,000
Dialup Lines	$20,000	$50,000
Support (4-5 staff per district)	$112,200	$255,000
Training	$16,500	$38,500
Total:	$158,700	$385,500
TOTAL U.S. ONE-TIME COSTS	**$49.25 B**	**$112.67 B**
One-Time Costs Per Student	**$1,119.42**	**$2,560.68**
TOTAL U.S. ANNUAL COSTS	**$3.57 B**	**$10.03 B**
Annual Costs Per Student	**$81.15**	**$228.01**

2.2.5 Cost Comparison of Models

Total U.S. expenditures on K-12 education in 1992-93 totaled $280 billion. Total one-time costs for the fourth model represent 3% - 7% of total national educational expenditures. The ongoing annual costs represent 0.6% - 1.6% of total national educational expenditures. For the fifth model, the costs are more significant, with one-time costs representing 18% - 41% of total national educational expenditures.

The models of advanced connectivity include significant equipment and training costs, which may be beneficial for other educational purposes in addition to networking. Looking beyond these cost items, the difference in costs between the fourth and fifth models is less significant. Table 6 summarizes the associated range of costs for the various technology models.

Table 6. Total One-Time and Ongoing Costs for Associated Models

	One-time		Ongoing	
	Low	**High**	**Low**	**High**
Single PC Dialup	$0.07 B	$0.37 B	$0.11 B	$0.43 B
LAN w/Shared Modem	$2.01 B	$6.08 B	$1.18 B	$2.68 B
LAN w/ Router	$4.13 B	$10.49 B	$1.22 B	$3.38 B
LAN w/Local Server & Dedicated Line	$9.19 B	$22.05 B	$1.74 B	$4.61 B
Ubiquitous LAN w/Hi-speed Connection	$49.25 B	$112.67 B	$3.57 B	$10.03 B

2.3 POTENTIAL IMPACT OF COST REDUCTION INITIATIVES

Much more can be done by the government and the private sector to significantly mitigate the costs that schools face in developing network connectivity. This section will examine some possible programs and their impact on the costs to schools.

The baseline for NII access is model four with a LAN, local server, and dedicated line to the district hub. Table 7 provides a summary of the costs for this model.

Table 7. Total U.S. Costs (in $ Millions) for Model Four Level Connectivity

	One-time Costs		Ongoing Costs	
Component	Low	High	Low	High
Local Area Network	$1,715	$4,750	$0	$0
Personal Computers	$5,100	$10,200	$0	$0
File Server	$243	$1,500	$0	$0
Telecommunications Lines	$298	$725	$115	$500
Router and CSU/DSU	$221	$425	$0	$0
Retrofitting	$850	$2,125	$0	$0
Training	$750	$2,250	$225	$525
Internet Service	$0	$0	$150	$630
Support	$0	$0	$990	$2,250
Replacement of Equipment	$0	$0	$255	$701
Total:	**$9,176**	**$21,975**	**$1,735**	**$4,606**

Using these costs, it is apparent that various cost-saving programs will have different effects on the bottom line for schools. This section describes nine possible programs and their cost saving effects on schools. Table 8 summarizes the potential savings for each of the programs.